Composting – A Manure Treatment Technology

<u>How Composting Works</u>

Composting is the aerobic, or oxygen-requiring, decomposition of organic materials by microorganisms under controlled conditions. During composting, microorganisms consume oxygen (O_2) while feeding on organic matter. Active composting generates considerable heat and large quantities of carbon dioxide (CO_2) and water vapor are released into the air. CO_2 and water losses can amount to half the weight of the initial materials. Composting reduces both the volume and mass of the raw materials while transforming them into a valuable soil conditioner.[1] Composting dairy manure reduces odors, kills pathogens, stabilizes the manure for easier handling, and allows storage of phosphorus until it is moved to fields or off-farm completely. Compost is a valuable soil amendment with many benefits including the potential to suppress pests including plant diseases. [2]

The major groups of microorganisms that participate in composting are bacteria, fungi, and actinomycetes. Bacteria are small, simple organisms. They exist in a wide variety of forms and environmental conditions. In composting, they are the most numerous of the three groups of microorganisms. They are generally faster decomposers than other microbes. Fungi are larger organisms. Many fungi form networks of individual cells in strands or filaments. They are more tolerant of low-moisture and low-pH conditions than bacteria but are less tolerant of low-oxygen environments. Actinomycetes form filaments like fungi; but because of their small size and cell structure, they are technically classified as bacteria. They tend to become more pronounced after the easily degraded compounds are gone and when moisture levels are low. Bacteria tend to flourish, especially in the early stages of composting, before the easily degraded materials are consumed. Fungi and actinomycetes become more important near the end of composting process feeding on the difficult to breakdown materials. [1]

During composting, these microorganisms transform organic raw materials into compost by breaking down the raw materials into simple compounds and reforming them into new complex compounds. In this process, the amount of humus increases, the C:N ratio decreases, pH neutralizes, and the exchange capacity of the materials increases. During composting some loss of nitrogen may occur and ammonia can escape from the composting pile. Nevertheless, composting retains most nutrients supplied by the raw materials and stores them within stable organic compounds. The microorganisms, by breaking the chemical bonds of the organic materials, obtain energy for growth. During this process, some of the chemical energy is transformed to heat that increases the pile temperature and escapes to the surroundings. Microorganisms decompose organic materials progressively, breaking them down from complex to intermediate to simple compounds. The nutrients that become available during decomposition remain in the compost within the bodies of new microorganisms and as humus. The final product has a low rate of microbial activity but it contains microorganisms, nutrients and the remains of microorganisms. [1]

Factors fundamental to the composting process include oxygen and aeration; nutrients (C:N ratio); moisture; pile structure; pH; temperature; and time.[1]

Aerobic composting consumes large amounts of oxygen. In addition to providing oxygen, aeration removes heat, water vapor and other gases trapped within the composting materials. The required rate of aeration for heat removal can be ten times greater than that for supplying oxygen. [1]

Carbon (C), nitrogen (N), phosphorus (P), and potassium (K) are the primary nutrients required by the microorganisms involved in composting. A C:N ratio of around 30:1 usually ensures that the other required nutrients are present in adequate amounts.[1]

Moisture is necessary to support the metabolic processes of the microbes. Water provides the medium for chemical reactions, transports nutrients, and allows the microorganisms to move about.[1]

Pile structure is defined by the physical properties of the materials, their porosity, structure, and texture. These properties affect the composting process by their influence on aeration.[1]

pH - The composting process is relatively insensitive to pH, within the range commonly found in mixtures of organic materials, largely because of the broad spectrum of microorganisms involved.[1]

Temperature – Microorganisms are classified into two temperature ranges in which they thrive. Composting occurs within two ranges –mesophilic (50 -105° F) and thermophilic (over 105° F).[1]

Time – The length of time required to transform raw materials into compost depends upon many factors including the materials used, temperature, moisture, frequency of aeration, and user requirements.[1]

Advantages of Composting Dairy Manure

Composting reduces bulk, pathogens, and odors and yields a useful soil amendment. While the nitrogen in compost is not as readily available as the nitrogen in manure, the availability of potassium, phosphorous, and micronutrients from compost is similar or higher than that from manure. An optimal C:N ratio will prevent nitrogen loss and ensure rapid composting. Compost can be applied more uniformly and with better control than manure and can also be stored and applied when convenient. Compost or co-compost (compost made from manure and municipal green material) is a value-added soil amendment that can be a source of income and if moved offsite removes surplus nutrients from the farm's nutrient cycle.

In California, a dairy that sells or gives away less than 1000 cubic yards of compost made exclusively from on-farm materials (manure) is not subject to the CIWMB's permitting requirements. Dairies that sell or give away more than 1000 cubic yards of compost (annually) made from on-farm materials are subject to Enforcement Agency notification (no permit required), the State's minimum standards and annual inspections. [14 CCR 17856] CIWMB on-farm compost regulations allow a considerable amount of municipal green material to be brought on the dairy for composting. If less than 1000 cubic yards of compost is sold or given away, an unlimited amount of green material can be brought on-site for composting. If more than 1000 cubic yards of compost are sold or given away, the dairy can compost up to 12,500 cubic yards of green material on-site at any one time. Under both of these scenarios, the dairy would be required to notify the Enforcement Agency (no permit required), be subject to State minimum standards, and inspections. [14 CCR 17856]

Disadvantages of Composting Dairy Manure

Composting transforms the nutrients found in manure, but it does not remove nitrogen and phosphorus, which are potential water pollutants. Other disadvantages of composting include potential odors, loss of nitrogen, VOCs, large land requirement (footprint), extended processing and curing time, expense of equipment, and the challenge of developing a successful marketing plan for compost.

Composting manure will most likely require dewatering (solids separation) as a pre-treatment, which means that a significant portion of the nutrients and salts do not enter the composting process, and must be treated separately.

Implementation Status

Composting has been widely applied on farms as a form of manure management in California.

Overarching Lessons - Composting and California Dairies.

Composting as a Manure Management Technology – The existing manure management techniques present the environmental challenges of air quality and water quality impacts. Composting as a manure management alternative can provide answers to some of these environmental challenges. Although composting manure and selling it to end markets outside of the agriculture industry can be advantageous, this approach diverts the nutrients, organic matter, and soil-building qualities of the manure from cropland. When the agriculture industry, in turn, buys commercial fertilizers to make up for the lost nutrients, this may not make good economic or agronomic sense. Composting manure and applying the compost to agricultural lands is a good life cycle solution that addresses the environmental concerns of manure management and maintains the nutrient and soil-building benefits of this nutrient-laden organic material.

Types of Composting - There are many types of composting systems from static piles to turned windrows to positive aerated-static-piles (ASP) to negative ASP to enclosed facilities with biofilters and scrubbers, each with their inherent attributes. In general these composting processes are increasingly more expensive to operate but provide greater composting efficiencies and/or environmental protections.

Water Quality Issues - In general, composting manure will most likely require dewatering (solids separation) as a pre-treatment, which means that a significant portion of the nutrients and salts do not enter the composting process, and must be treated separately. Composting provides an alternative to capture some of the nitrogen as organic nitrogen, a nutrient in the compost product, rather than generating ammonia or nitrates as is the case with land application of manure.

Air Emission Issues – Dairy manure composted in open windrows will emit less ammonia and VOCs as compared to manure that is naturally degraded (biogenic). Biofilters can be incorporated into the compost process and can reduce emissions by 90-95%. Manure composted in an uncovered negative aerated static pile, where variable speed blowers maintain a continual negative pressure on the compost pile and discharge the air for secondary treatment in a biofilter, can achieve a high emission reduction efficiency. One emission test estimated the overall capture efficiency of VOC emissions from the pile and biofilter (negative ASP) at 72%.

Funding – Composting on a dairy requires equipment, labor, and management. On farm dairy manure composting could easily exceed $100,000, depending on the equipment purchased. Enclosure, ASP, biofilter operations cost several million dollars.

Co-composting - Co-composting dairy manure with municipally derived green material can improve the quality of composted manure and provide a revenue stream (tip fees) for the dairy. CIWMB on-farm compost regulations allow a considerable amount of municipal green material to be brought on the dairy for composting. If less than 1000 cubic yards of compost (made from manure and green) is sold or given away by the dairy, an unlimited amount of green material can be brought on-farm for composting. If more than 1000 cubic yards of compost is sold or given away, the dairy can compost up to 12,500 cubic yards of green material on-farm at any one time. Under both of these scenarios, the dairy would be required to notify the Enforcement Agency (no permit required), be subject to State minimum standards, and inspections. [14 CCR 17856]

Enforcement Agency Notification, Minimum Standards, & Inspections - In California, Enforcement Agency notification, processing standards, and inspections are required if a dairy sells or gives away more that 1000 cubic yards of on-farm derived compost, or if a dairy brings municipal green material on-site for composting. A permit from the CIWMB is not required.

Summary - Composting dairy manure on-farm or at a regional facility may be viewed as one part of the solution to manage dairy manure. Depending on the method, composting may be a costeffective means to reduce dairy's environmental impact. In addition, co-composting the manure with green material may enhance the compost and economics of the operation.

References

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